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Overtraining in two-cue discrimination learning in rats

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OVERTRAINING IN TWO-CUE DISCRIMINATION LEARNING IN RATS

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Chapter I

Problem and Review of the Literature

Recent evidence indicates two processes are involved in discrimination learning (Lovejoy, 1966; Mackintosh, 1965). It is postulated that a S must first attend to the relevant stimulus dimension and then attach responses to stimuli that are impinging on the organism from the stimulus dimensions. There is, however, an important question left unanswered in two-stage formulations: the number of stimulus dimensions or cues a S is capable of attending to simultaneously.

Lovejoy's mathematical model has successfully skirted the issue. In his two-process model he has been content to deal with a single relevant stimulus dimension, concentrating on attention or nonattention and not becoming involved with the number of cues a S is capable of attending to.

Mackintosh, on the other hand, has considered the question of the number of cues it is possible for an animal to attend to simultaneously. Mackintosh has postulated that an animal cannot attend equally to all stimulus dimensions that are impinging upon it from the total stimulus situation. He has hypothesized that due to the restrictions placed on the animal by a limited nervous system it must eliminate irrelevant or redundant information. This formulation indicates a S attends primarily to a single cue, and that its performance will be controlled by this dominant cue. Mackintosh does not rule out the possibility that learning about a less preferred cue or cues can take place, but he has hypothesized that the more an animal attends to one cue the less it will attend to a second cue or cues. Mackintosh has indicated overtraining will result in increased learning about a dominant cue but that there will not be an increase in learning about less preferred cues, and that a negative correlation between performance on one cue and performance on a second will result.

Additional experimental evidence (Sutherland & Holgate, 1966) suggests a modification in Mackintosh's position. While holding a position very similar to Mackintosh, Sutherland and Holgate postulate overtraining can result in an increase in learning about a preferred cue and in learning about a remaining cue or cues. To test this hypothesis they gave Ss 200 training trials in a Lashley jumping stand on a two-cue discrimination problem, using brightness and orientation of cues as stimulus dimensions. At the conclusion of 200 training trials on the two-cue discrimination problem the Ss were tested on a single-cue problem, followed by extinction on both the two-cue and the single-cue problem.

The results of the experiment indicated that the more a S learned about a preferred cue the more that was learned about less preferred cues, while at the same time yielding the negative correlation between preferred and less preferred cues that Mackintosh had postulated. Thus, Sutherland and Holgate concluded the amount of learning about a less preferred cue will not equal the amount of learning about a preferred cue.

Sutherland proposed a formal model which he believed would allow for the negative correlation between the amount learned by a S and account for the S attending to more than one cue simultaneously. He has postulated different cues in a discrimination problem possess different probabilities of being attended to, the probability depending upon the conspicuousness of the cue. The maximum combined probability of attending to cues present is a fixed amount with a sum of less than one. However, the probability of attention to a single cue can vary between trials, and the amount of this variation is relative to the combined probability of attention to remaining cues. The variation will allow for learning to take place about less preferred cues, but as the probability of a less preferred cue will never equal that of a preferred cue, the amount of learning will never be equal between cues, and a negative correlation between the scores will result.

Mackintosh agreed that learning about a preferred cue and remaining cues was possible, but that more learning about a preferred cue will not result in increased learning about remaining cues. Sutherland and Holgate's experimental evidence suggests that increased learning about a preferred cue will also result in an increase in learning about remaining cues but that the amount of learning taking place about remaining cues will never equal the amount learned about a preferred cue. Thus, both Sutherland and Holgate and Mackintosh have suggested overtraining will not result in equal mastery of cues in a two-cue discrimination problem.

The present experiment was designed to produce additional experimental evidence on the effects of overtraining on attention in a two-cue discrimination problem. It was the contention of the present study that Sutherland and Holgate's failure to obtain equal mastery of cues was due to insufficient training. If training had been prolonged far enough equal mastery of cues should result. That is, if Ss were overtrained on a two-cue discrimination problem and tested for level of performance on each cue separately at the end of overtraining Ss would perform at near 100% on the test.

Chapter II

Method

Subjects. Ss were 48 male Sprague-Dawley rats from Simonson Labs, Gilroy, California and were 59 days old at the start of training. Ss were weighed upon receipt and once again at the end of a five day period of free access to food. This procedure enabled the E to determine normal body weight of the Ss. Throughout the study body weights were monitored and minor adjustments in daily ration made in order to maintain the Ss at approximately 90% of normal body weight. Ss were placed on a 23½ hour deprivation schedule.

Apparatus. Apparatus consisted of a T-maze, flat black in color. (see Figure 1).

Stimulus dimensions. Stimulus dimensions consisted of visual and kinesthetic cues. Visual cue was provided by two #47 dial lights placed 7 inches from the choice point. The lights were placed to enable the E to illuminate each arm of the maze independently. The kinesthetic cue consisted of a step-down placed across each arm of the maze placed 7 inches from the choice point, and was 1 inch deep and 4 inches long. The maze was so constructed to enable the E to eliminate the kinesthetic cue by inserting

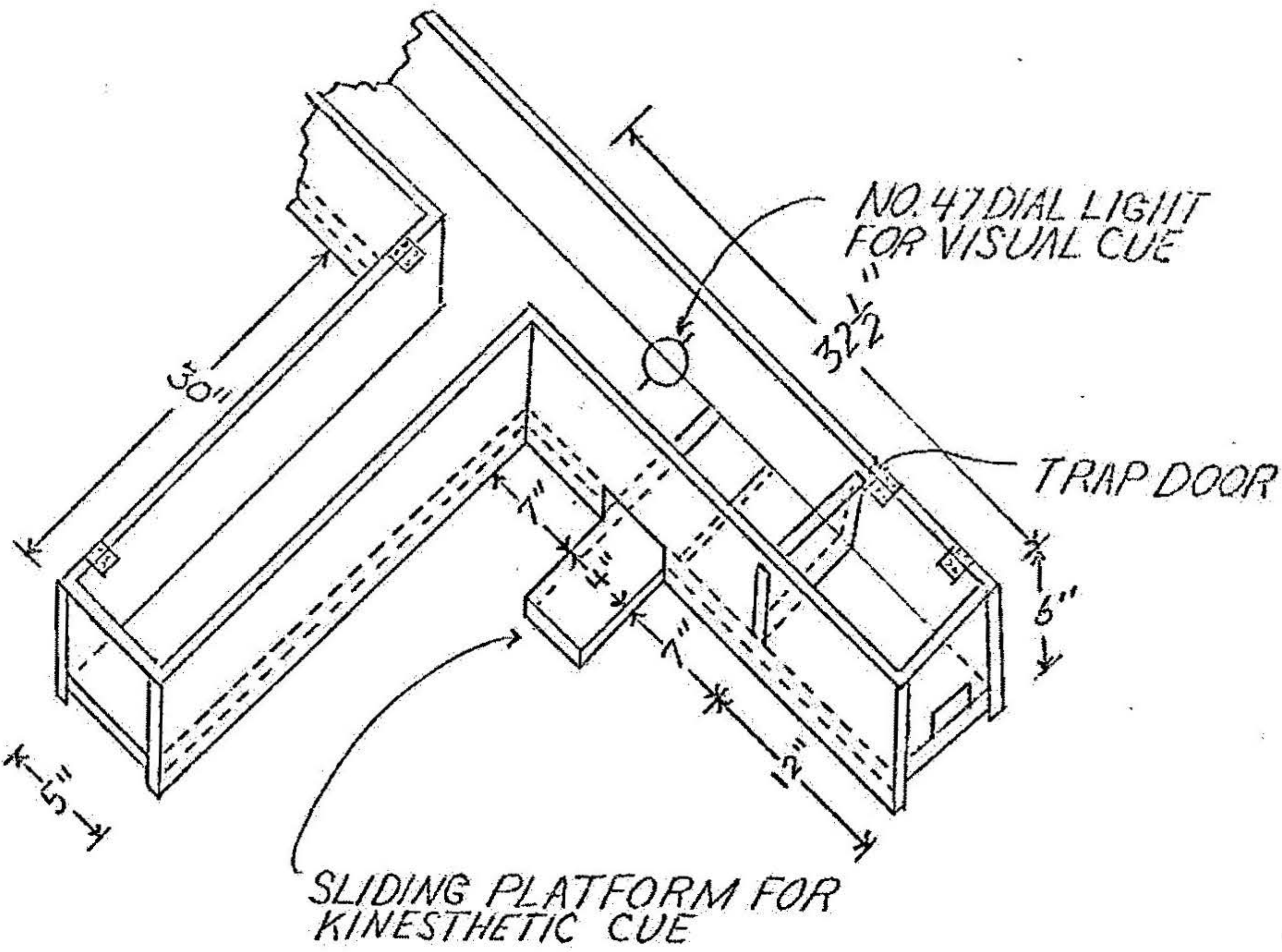

Fig. 1. Apparatus

a 1 inch x 4 inches block into the depression. Control of the visual cue was provided by a pair of switches operated by the E. A knife switch was used to allow each arm to be lighted independently, and a second switch was used to enable the E to present the visual cue when Ss reached a point 7 inches down the arm from the choice point.

Exposure to cues was kept equal in training and testing. This was accomplished by placing a piece of plexiglass 7 inches from the choice point in each arm. As the animal entered the kinesthetic cue area the E manually lighted the visual cue and it remained lit until the animal entered the goal box, at which time the visual cue was switched off.

Prehandling. Each S was placed in a box 4 feet wide and 2 feet deep for 3 minutes per day for 6 days. In the center of the box six 45mg. Noyes food pellets were placed in a small glass container.

Pretraining. All Ss received pretraining in the maze. Throughout pretraining both arms of the maze were illuminated by means of the dial lights and both step-downs were filled. Pretraining was continued for 6 days. On the first day of pretraining each S received free exploration of the maze for one trial. Reward in the form of six 45mg. Noyes food pellets was available in both goal boxes, and Ss were removed from the maze upon obtaining reward in either goal box. The second day of pretraining followed the same procedure as on the first. The third day of pretraining consisted of two trials. A forcing procedure was used contingent on the performance during the two previous pretraining trials. In the event a S responded with a right and a left on the first two trials the third trial consisted of free exploration and on the fourth trial the animal was forced to the side opposite the side the S chose on the previous trial. If the S responded with two rights or two lefts on the first two trials the third trial was forced. To insure equal experience with both arms of the maze the same forcing procedure was followed on the four trials of the fourth day, the eight trials of the fifth day and the ten trials of the sixth day.

Training. A correction procedure was used throughout the experiment. That is, if an animal made an incorrect choice it was allowed to return to the opposite side and receive reward before being removed from the maze. Each S was trained for 10 trials in succession daily, 6 days per week, with both visual and kinesthetic cues present and relevant. Cue position was varied according to the sequences of Fellows (1967). Criterion for Ss consisted of 10 consecutive correct trials. All Ss continued training until all Ss reached criterion. Once all Ss reached criterion overtrained Ss received an additional 300 training trials.

Testing. During testing procedure a single relevant cue was presented on each of 20 trials, 10 trials per day. The actual cue presented alternated between the kinesthetic and the visual cue, and its position was alternated between the left and right sides of the maze. Whether a S was first tested on the kinesthetic or visual cue was decided on a random basis. Half of the nonovertrained Ss were tested at criterion, and half were tested at completion of overtraining by overtrained Ss. This procedure was followed to control for the time differential between the cessation of training and the beginning of testing for the overtrained Ss. The same procedure was followed by overtrained Ss, with half tested at a point equal to the time required of non-overtrained Ss to wait following the cessation of over-training.

Experimental design. The experimental design was a 2 X 2 X 2 X 2 factorial design with two between-subjects factors and two within-subjects factors. The between-subjects factors were level of overtraining, none and 300, and time of testing, immediate and wait. The within-subjects factors were type of cue producing S errors, kinesthetic or visual and place where error occurred, rewarded or nonrewarded arm of the maze. Initially there were 10 Ss per cell, but during the course of the experiment it was discovered the discrimination required of the Ss was more difficult than at first expected. At the completion of 470 trials four Ss in each cell had reached criterion, and due to the time element training was concluded at that point.

Chapter III

Results

A record of total errors for each S was maintained over the 20 testing trials. Table 1 presents a summary table of the analysis of variance on this data. The analysis of variance revealed significant main effects for cue ($F = 14.531$, $p < .01$) and location of reward in regard to errors ($F = 12.936$, $p < .01$). The remaining main effects and the interactions were found to be not significant.

The significant main effect of cue is caused by the kinesthetic cue resulting in fewer errors (an average of 4.25) than the visual cue (an average of 15.88) during testing. The significant main effect of reward is due to the fact Ss made more errors on the nonrewarded side of the maze (an average of 10.50 errors) than on the rewarded side (an average of 5.38 errors).

TABLE 1

Summary Table of Analysis of Variance

Source	df	MS	F
Overtrain (O)	1	5.640	3.312
Time (T)	1	.140	.082
O X T	1	4.516	2.652
Within	12	1.703	
Reward (R)	1	26.265	14.531*
O X R	1	3.517	1.946
T X R	1	6.891	3.814
O X T X R	1	.390	.216
R X Subjects Within Groups	12	1.807	
Cue (C)	1	54.390	12.936*
O X C	1	15.016	3.573
T X C	1	13.142	3.127
O X T X C	1	9.765	2.323
C X Subjects Within Groups	12	4.203	
C X R	1	3.517	.549
O X C X R	1	.764	.119
T X C X R	1	.764	.119
O X R X R X C	1	.017	.027
RC X Subjects Within Groups	12	6.407	

*$p < .01$

Chapter IV

Discussion

The hypothesis that equal mastery of cues would result with prolonged training was not supported by the present study. Rather it was found that Ss' performance was dominated throughout by the kinesthetic cue, and further that overtraining did not result in increased learning about either cue. These results were unexpected from the evidence obtained by Sutherland and Holgate (1966) and the predictions of Mackintosh (1965). Sutherland and Holgate's evidence indicated that prolonged training would result in increased learning about both preferred and less preferred cues, although not equal mastery of both cues. Mackintosh postulated that overtraining would result in increased learning about a preferred cue, but not about a less preferred cue. In the present study, however, the pertinent Overtraining X Cue interaction was not significant.

Mackintosh has discussed the subject of dominant cues and proposed that increased learning about a dominant cue is due to the conspicuousness of the cues themselves. Thus, the more conspicuous the cue the greater the probability of the S attending to it and the result being an increase in learning about the dominant cue. In terms of the present study the failure to achieve a significant improvement in performance of Ss with overtraining may be explained in terms of conspicuousness of cues. It must be emphasized that in the present study cues were not as obvious as they have been in almost all previous T-maze studies. In past studies Ss were exposed to cues for a longer period of time, and in many cases cue exposure continued whild Ss received reward in the goal box. In the present study cue presentation was continued for a brief period and was not present in the goal box. The evidence from the present study may suggest that increased learning may be a function of cue conspicuousness in addition to overtraining. That is, prolonged training may not result in increased learning about cues of low conspicuousness.

Cue conspicuousness may also be used to explain the significant main effect of location of reward in terms of errors. In the event the animal entered a rewarded side of the maze a decision was facilitated by the presence of cues. However, if the nonrewarded side was chosen the animal had to proceed into the arm of the maze and make a decision on the basis of the time and/or distance from the choice points. A decision based on the cues of time and distance presents Ss with an extremely difficult discrimination task. If a S selects the nonrewarded side it must proceed into the arm of the maze anticipating the presence or absence of cues. It is extremely difficult for a subject to determine at what point it can no longer anticipate encountering the cues, and the closer the animal gets to the goal box the greater the probability of it continuing into the goal area, and thus the greater the probability of an error. In order to eliminate this difficulty a means could be provided that would signal a point beyond which Ss would not receive the cues. A stripe painted on the floor of both arms of the maze could be used to eliminate this problem.

In the final analysis the evidence produced by the present study suggests that a parametric study should be conducted that would provide for a Conspicuousness of cues X Overtraining interaction. In such a study two groups would be trained to criterion, one with highly conspicuous cues and one with less obvious cues. This could be accomplished by providing the cues in series throughout the arms of the maze including the goal box. In this case the kinesthetic and the visual cues, rather than consisting of one brief presentation, would consist of constant exposure while proceeding down the arm of the maze and while receiving reward. Once criterion was reached overtraining could be introduced and the interaction of Cue conspicuousness X Overtraining examined.

Chapter V

Summary

The present study was designed to provide additional experimental evidence on the effects of overtraining in a two-cue discrimination problem. The present study differs from that of Sutherland and Holgate (1966) in that overtraining was continued for a greater number of trials.

*S*s for the present study consisted of 48 Sprague-Dawley rats, 59 days old. The experimental design was a 2 X 2 X 2 X 2 factorial with two within-subjects and two between-subjects factors. An analysis of variance on the data revealed significant main effects of cue and location of reward. The remaining main effects and the interactions were found to be not significant.

The results of the present study differed from those of Sutherland and Holgate in that overtraining did not result in increased learning about either cue as can be shown by the absence of a significant Overtraining X Cue interaction. Rather the evidence indicates that increased learning may be a function of cue conspicuousness in addition to overtraining.

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